should be used whenever potential noise level difficulties are anticipated.

Intake resistance to airflow should be no more than necessary to maintain air quality. The resistance created by the air intake system will reduce compressor performance and efficiency. Refer to the compressor manufacturer's manual for maximum resistance requirements.

Intake Filters

Air filters are provided on compressor intakes to prevent atmospheric dust from entering the cylinders and causing scoring and excessive wear. The two most common types of elements in use are the VISCOUS IMPINGEMENT and the OIL BATH. Both types are illustrated in figure 11-10.

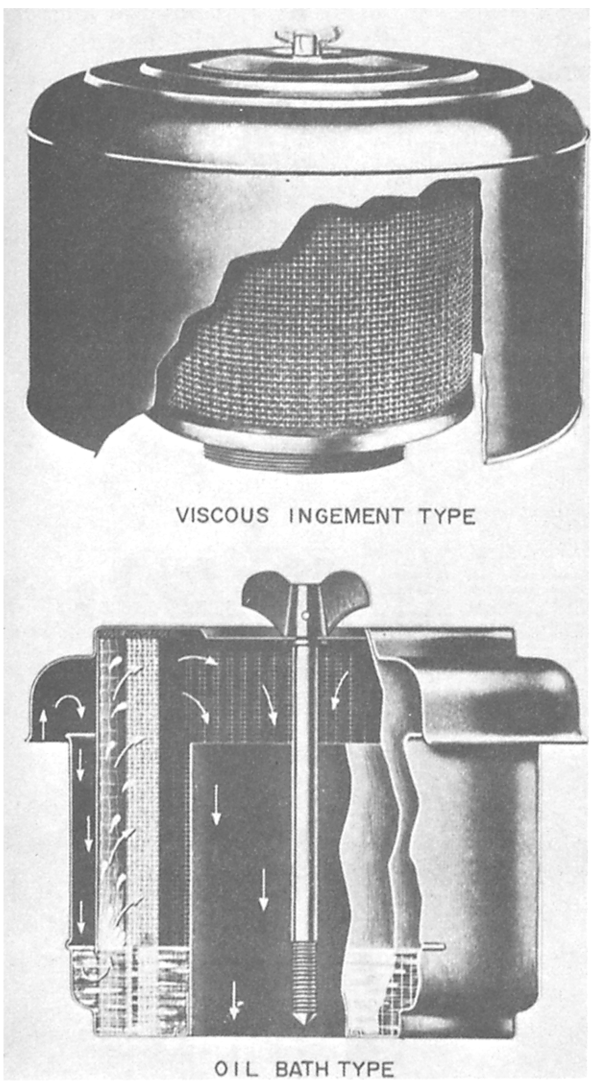

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Figure 11-10.—Compressor intake filters.

In the oil bath type, air must pass through an oil seal that removes dirt particles, and then pass on through a wire mesh element, which is saturated by oil carry-over. Any remaining particles of dirt are removed by the wire mesh element. Captured dust particles settle to a sump at the bottom of the filter housing. Oil bath filters are recommended where dust concentrations are present in the atmosphere.

The viscous impingement filter consists of a wire mesh filter element, which is coated with oil. Air passing through the filter element must change directions many times, causing any dust to adhere to the oil film.

Silencers

Silencers are similar to mufflers and function simply to eliminate objectionable compressor suction noise. Figure 11-11 illustrates a standard

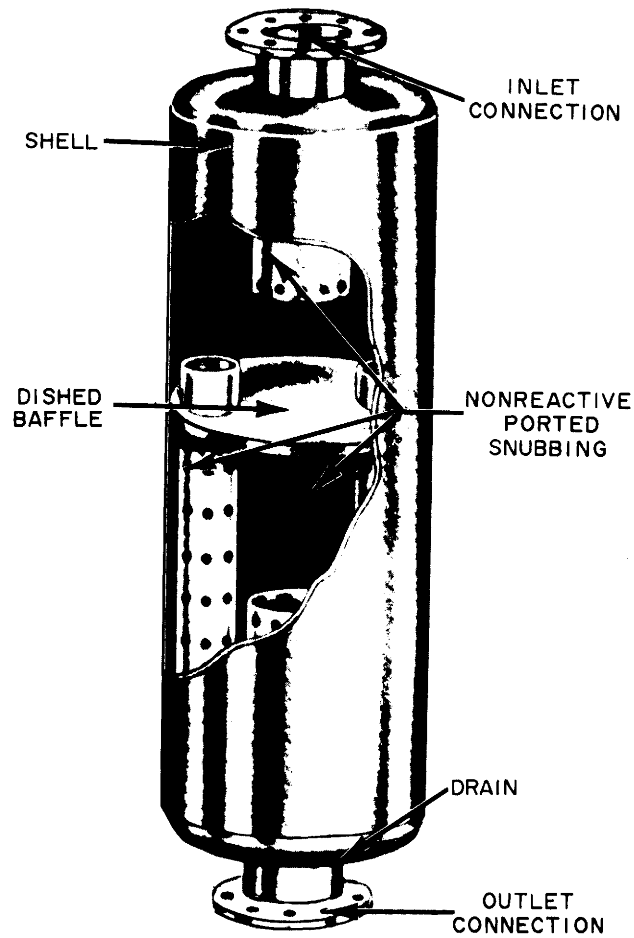

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Figure 11-11.—Intake silencer.

intake silencer. Some compressors are equipped with combination filter-silencer units that have the filter elements contained within the silencer housing.

Intercoolers

When air is compressed to 100 psi without heat loss, the final temperature is about 485°F. The increase in temperature raises the pressure of the air under compression, thus necessitating an increase in work to compress the air. After the air is discharged into the receiver tank and lines, the temperature falls rapidly to near that of the surrounding atmosphere, thereby losing part of the energy generated during compression. The ideal compressor would compress the air at a constant temperature, but this is not possible. In multistage compressors, the work of compressing is divided between two or more stages, depending on the final discharge pressure required. An INTERCOOLER is used between the stages to reduce the temperature of compression from each stage. Theoretically, the intercooler should be of sufficient capacity to reduce the temperature between stages to that of the low-pressure cylinder intake. Actually, intercooling has three purposes: to increase compressor efficiency, to prevent excessive temperatures within the compressor cylinders, and to condense out moisture from the air.

Most intercoolers are either the shell and tube, air-to-water heat exchangers or the air-cooled radiator-type heat exchangers. Figure 11-12 illustrates a typical water-cooled inter-cooler. The air-cooled type is shown in figure 11-3.

Aftercoolers

Moisture carried in air transmission lines is undesirable because it causes damage to air-operated tools and devices. AFTERCOOLERS are installed in compressor discharge lines to lower the air discharge temperature, thus condensing the moisture and allowing it to be removed. Also, the cooling effect allows the use of smaller discharge piping. A water-cooled aftercooler is illustrated in figure 11-13.

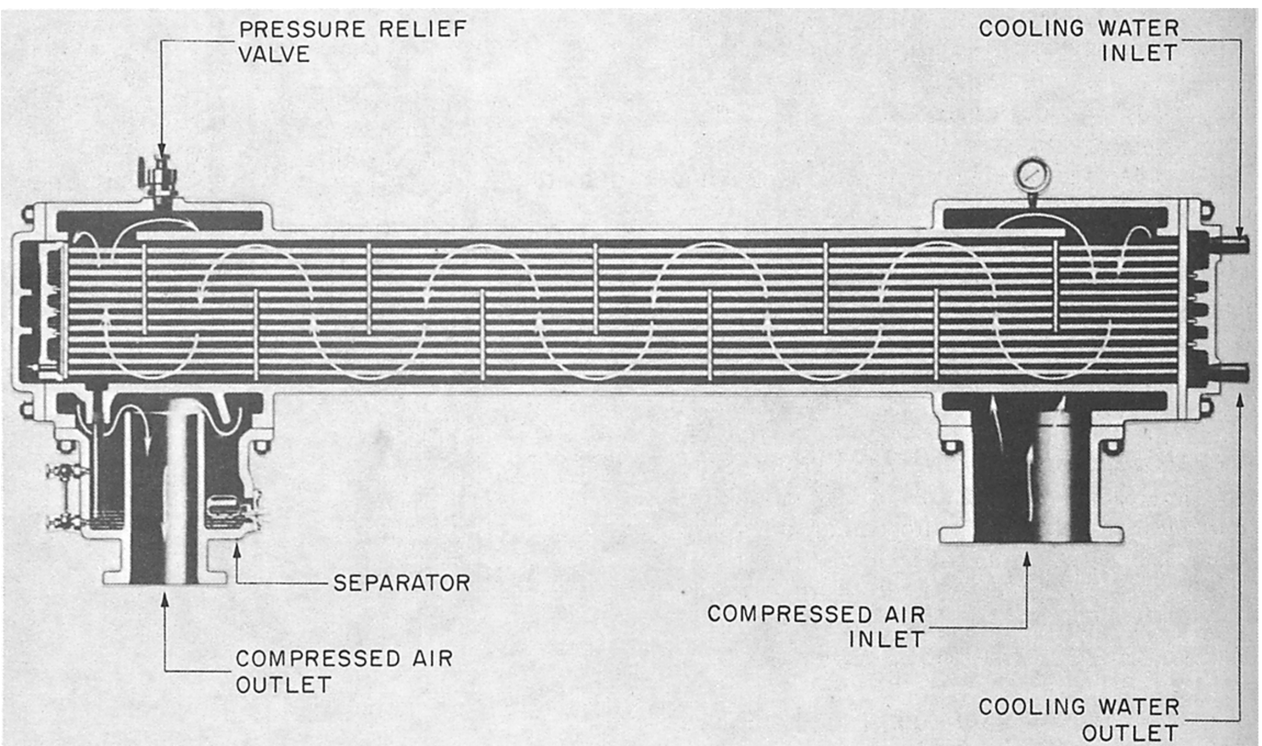

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Figure 11-12.—Typical water-cooled intercooler.

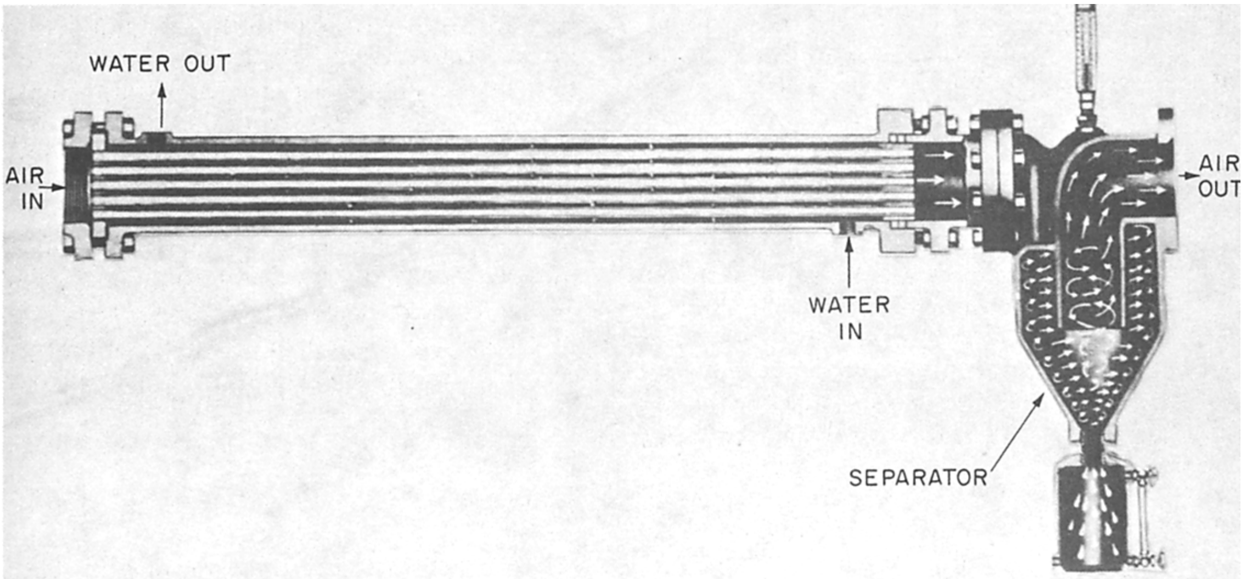

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Figure 11-13.—Typical water-cooled aftercooler.

Air Discharge Systems

Some discharge systems require special consideration for the placement of auxiliary equipment. All positive displacement compressors require a relief valve on their discharge side to protect the equipment and piping upstream of the first shutoff valve. Relief valves should be sized for at least 125 percent of the maximum unit flow capacity and should carry the American Society of Mechanical Engineers (ASME) stamp, listing the capacity and pressure setting of the valve.

Separators

Water and oil separators are required to separate and free excess water from the discharge air or gas. This is necessary to prevent corrosion, deposit buildup, and water or oil buildup in the piping or service. For example, water will cause rust in piping, wash away lubricants, and plug nozzles. Oil will contaminate many industrial processes and may present an explosion hazard. The need for water or oil separators will be determined by the end use of the compressed air.

A centrifugal separator is illustrated in figure 11-14. Air is directed into this unit in a manner that creates a swirling motion. Centrifugal force throws the moisture particles against the wall where they drain to the bottom.

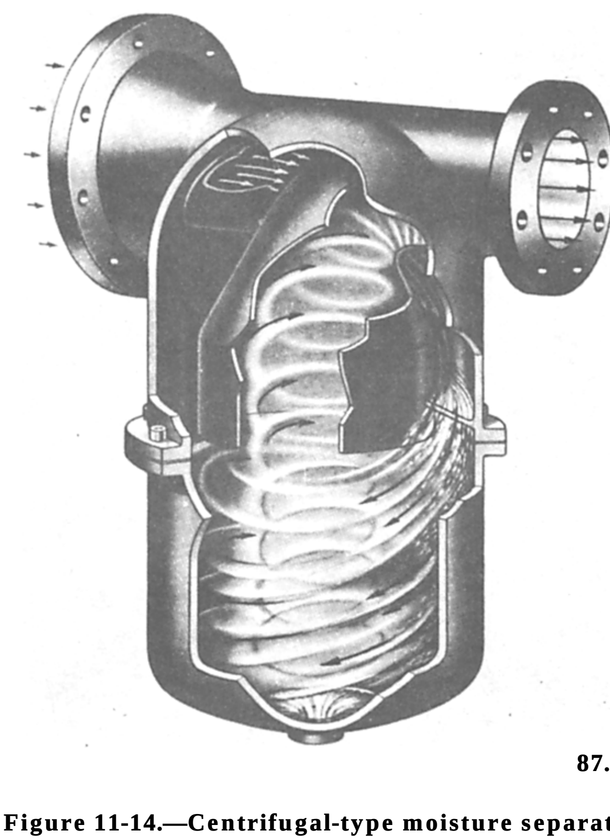

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Figure 11-14.—Centrifugal-type moisture separator.

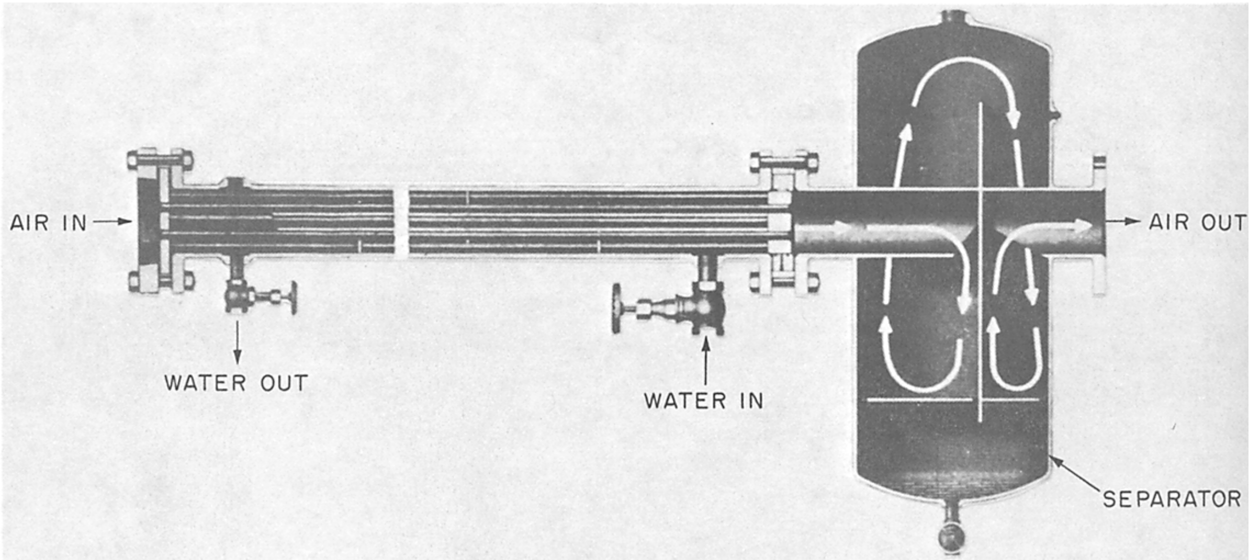

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Figure 11-15.—Baffle-type moisture separator.

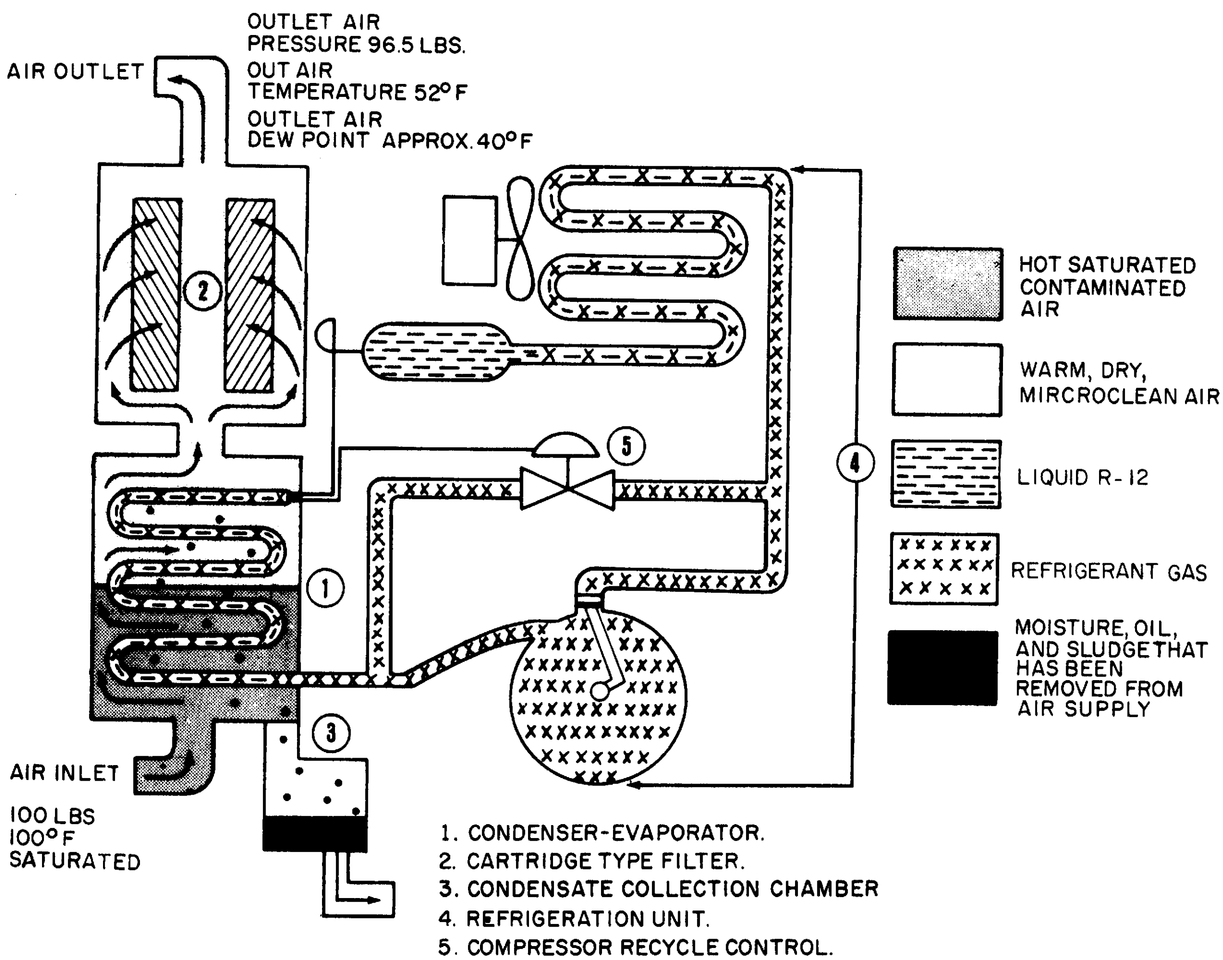

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Figure 11-16.—Flow process of refrigeration-type air dryer.

A baffle-type separator is illustrated in figure 11-15. In this unit the air is subjected to a series of sudden changes in direction that result in the heavier moisture particles striking the baffles and walls, then draining to the bottom.

Dryers

Some compressed air supplies require dryers that ensure removal of all moisture that might otherwise condense in air lines, air-powered tools, or pneumatic instruments. Small amounts of moisture can cause damage to equipment from corrosion, freezing, and water hammer and can result in malfunctions of instruments and controls. The cost of dryers is often justified by the reduction in maintenance costs, production time lost in blowing down piping, and compressed air lost during blowdown.

There are three basic designs of dryers: two absorption types and a condensation type. One type of absorption unit consists of two towers, each containing an absorbent material. Reactivation is accomplished by means of electric or steam heaters embedded in the absorbent or by passing dried-process air through it.

Another type of absorption unit consists of a single tank or tower containing a desiccant (drying agent) that dissolves as it absorbs moisture from the air and drains from the unit with the condensate. The drying agent must be replenished periodically.

The third type removes moisture from the air by condensation through the use of a mechanical refrigeration unit, or where available, cold water. Inlet air passes over cold coils where moisture is condensed out of the air and is drained from the unit by a trap. This process is illustrated in figure 11-16.

Receivers

Air receiver tanks in compressed air plants act as surge tanks to smooth the flow of air from the action of the compressor to discharge; they collect excessive moisture that may condense from the cooled air and provide a volume of air necessary to operate the pressure control system. A typical air receiver is shown in figure 11-17. Related components include a relief valve, pressure gauge, drain valve, service valve, and inspection opening.

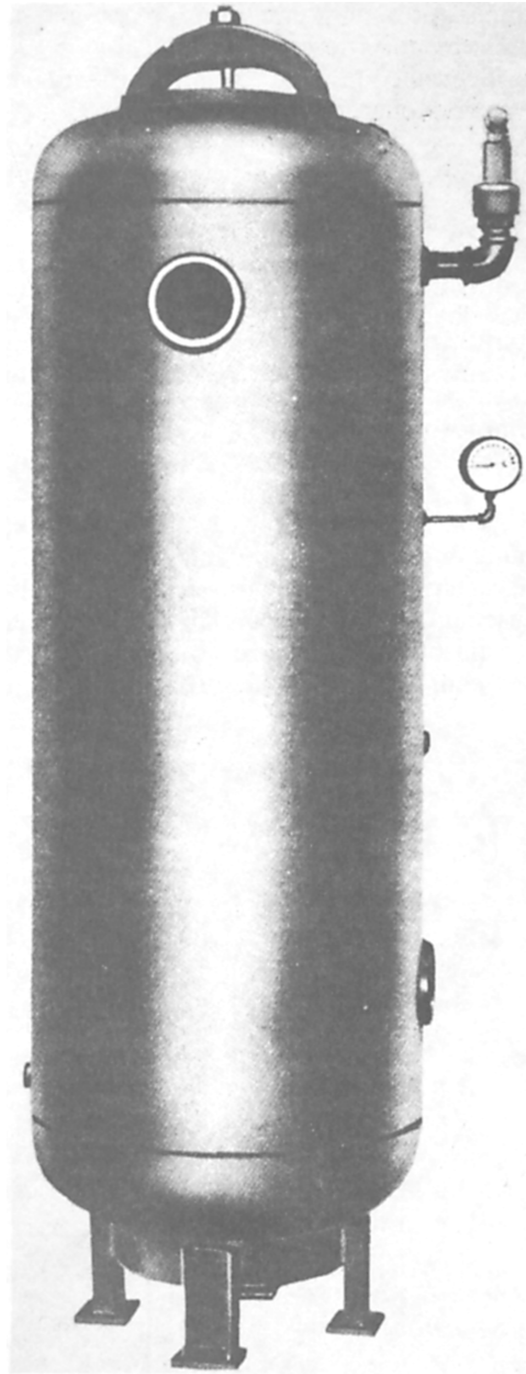

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Figure 11-17.—Air receiver.

Lubrication

Compressors must receive adequate lubrication using clean oil of characteristics recommended by the compressor manufacturer. The manufacturer will usually specify oil requirements by characteristics, such as viscosity at one or more temperatures, pour point, flash point, and in some cases, by specific brands.

Typical compressor cylinder oils will have the following characteristics:

Flash point, °F	350	minimum
Viscosity at 210°F	45	min - 90 max
Pour point, °F	+35	maximum
Neutralization number	0.10	maximum
Conradson carbon residue, %	2.0	maximum

Where cylinder lubrication is separate from frame and bearing lubricants, a modified set of characteristics may be specified. Synthetic oils must conform to the manufacturer's requirements and must be used with care as many synthetic oils may cause swelling and softening of neoprenes and certain rubbers or may not be compatible or separable from water.

Some special considerations for lubricants include the provision of a lubrication oil heater to ensure adequate viscosity during cold weather start-up. High compressor discharge temperatures require lubrication flows and characteristics that still lubricate when subjected to 300°F or higher discharge air temperature conditions. Finally, oil injection or oil-flooded compressors need adequate oil flow and characteristics to maintain lubrication of temperatures within the cylinders or screws.

A typical lubrication arrangement is shown in figure 11-18.

Discharge Pulsation

Reciprocating compressor discharge lines are subject to pulsations caused by the compressor-forcing frequency. This sets up a resonant frequency in the discharge piping, and the resulting vibration amplification will cause noise, support damage, and piping damage. There

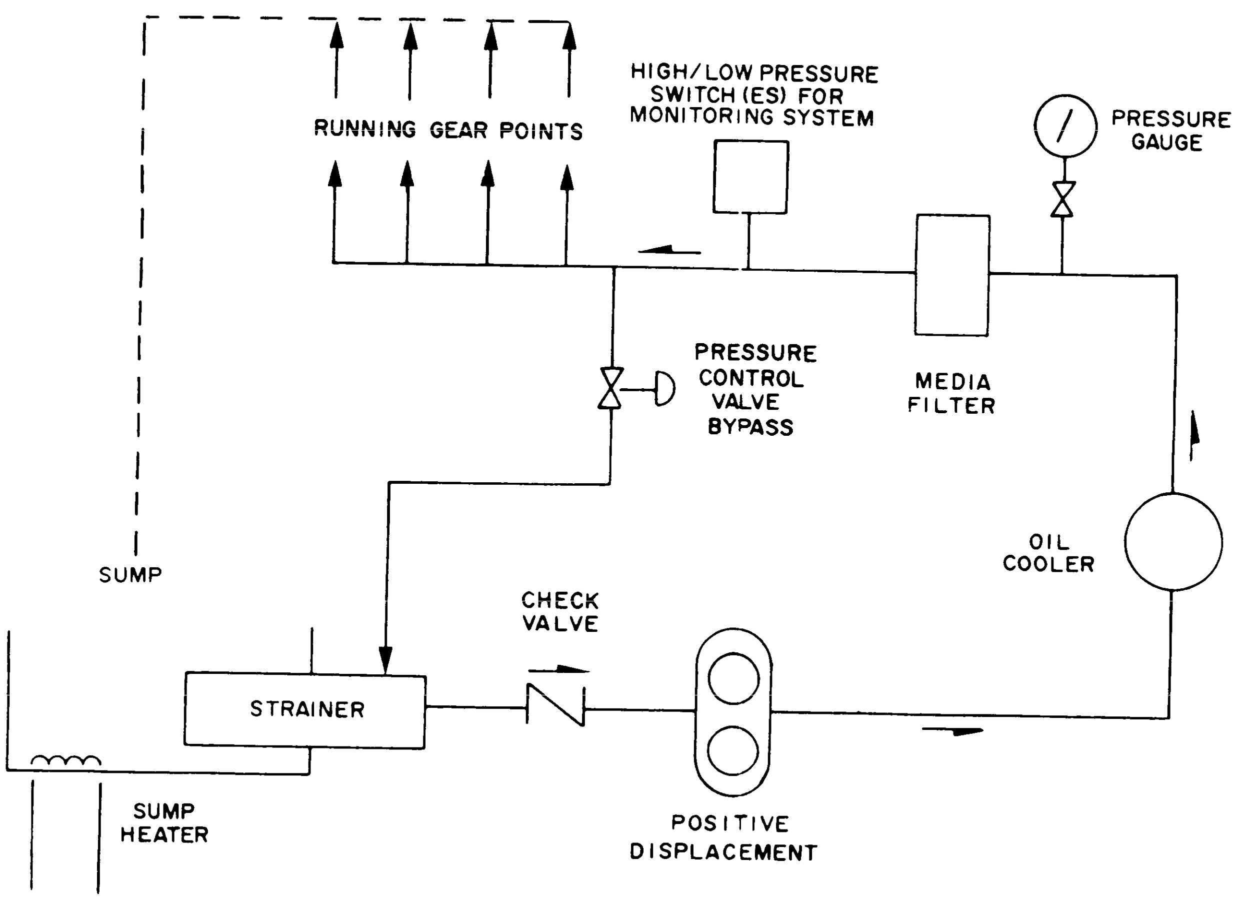

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Figure 11-18.—Typical pressure lubrication system.

is no single solution to this problem, but some specific guidelines will be discussed below.

Pulsation dampeners serve as pulsation and noise mufflers by providing acoustical chambers with the dampener. Manufacturers generally provide dampeners to a specified discharge pulsation peak of ± 2 percent of line pressure. Figure 11-19 shows several typical pulsation dampeners. These units should be used whenever reciprocating and centrifugal compressors serve the same compressed air main, because the pulsations of the reciprocating compressor can transmit to and disturb the operation of the centrifugal compressor. Pulsation dampeners may not completely solve downstream resonance, but they will reduce the vibration amplitudes.

Several other ways to decrease noise and amplification caused by discharge pulsation are available. Surge chambers can be used to change the equivalent length of the piping and increase the pulse-absorbing volume of the pipe. A surge chamber can be as simple as an increased diameter of discharge piping near the compressor discharge. An orifice plate or plates may be installed in conjunction with surge chambers to change the acoustical resonant frequency of the piping system. Piping support is also important at the compressor. They must not only be supported from top or bottom but also have lateral support. When piping is large, provide spring-loaded two-way lateral supports to absorb vibration.

Controls

Compressor control systems generally include one or more controlling devices, such as safety controls, speed controls, and capacity controls. Such devices function in the system to regulate the output of the compressor as it meets the demand for compressed air.

On some small compressors the simple Bourdon tube-type pressure switch serves as a controller by actuating the prime mover on and off over a predetermined pressure range. More complex compressors require control systems that load and unload the compressor as air demands change. The CONSTANT-SPEED type of controller used with many compressors decreases or increases compressor capacity in one or more steps by the use of unloading devices, while allowing the prime mover speed to remain constant. Another type, referred to as the DUAL-CONTROL, is a combination of the constant-speed and an automatic start-stop control. It permits constant speeds when demands are continuous and an automatic stop or start when demands are light. There is still another system that enables the prime mover to idle and compressor suction valves to remain open when air pressure reaches a set maximum. As the pressure drops below a set minimum, the prime mover speed is increased, suction valves are closed, and air is compressed.

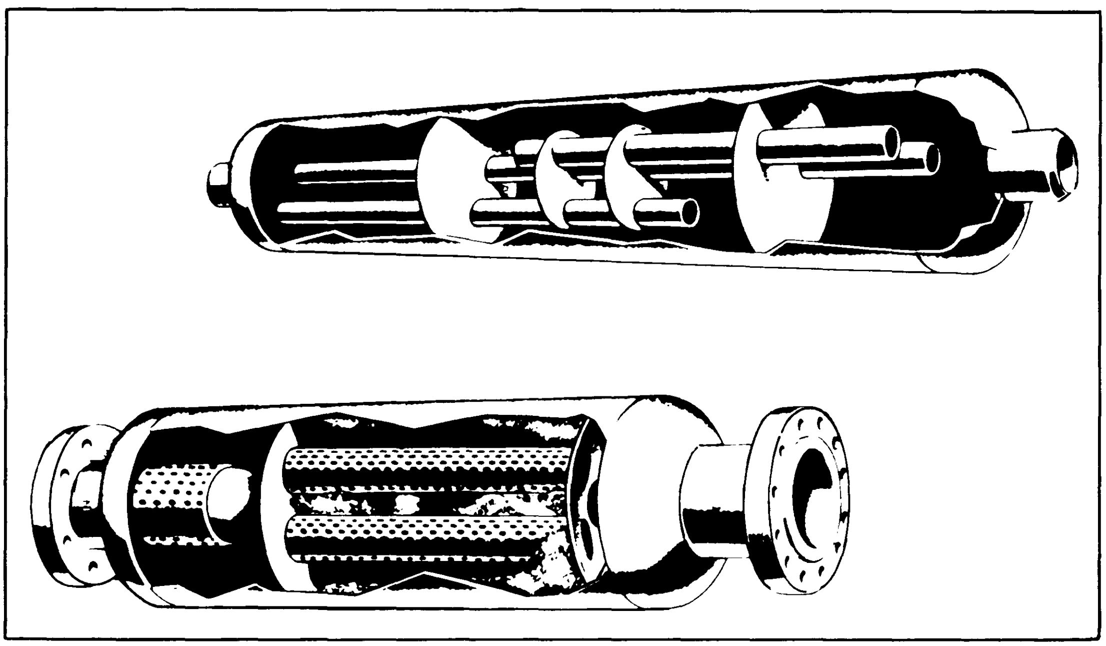

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Figure 11-19.—Pulsation dampeners.

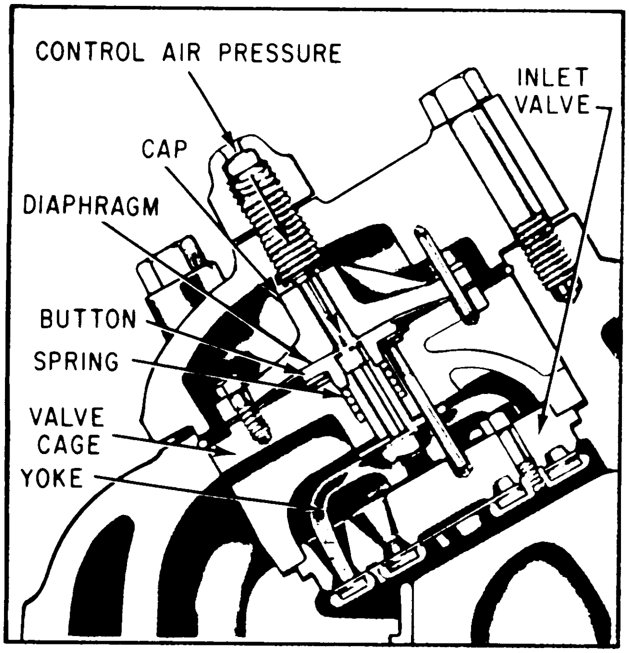

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Figure 11-20.—Inlet valve unloader.

Generally, control systems include unloading devices that function to remove all but the friction loads on compressors. Thus starting is unaffected by compression loads. Various types of unloading devices are discussed below.

The inlet-valve-type unloader holds the inlet valve open mechanically during both the suction and compression strokes, thereby preventing compression. Figure 11-20 illustrates a common inlet valve unloader. The unloader is positioned above the inlet valve. When air pressure rises to the preset unloading pressure, a pressure switch operates a solenoid unloader valve, which opens and allows receiver pressure to the inlet valve unloader. The pressure from the receiver, acting on the diaphragm of the inlet valve unloader, forces the yoke fingers against the inlet valve, holding it open. The intake air is pushed back out the inlet valve on the compression stroke so no compression takes place.

Figure 11-21 illustrates the thin plate, low-lift type of compressor valve. Most compressors use this type of valve.

The use of an unloader valve on each cylinder and a pressure switch with a solenoid unloader valve provides a step or sequenced capacity control. Figure 11-22 illustrates a flow diagram of a

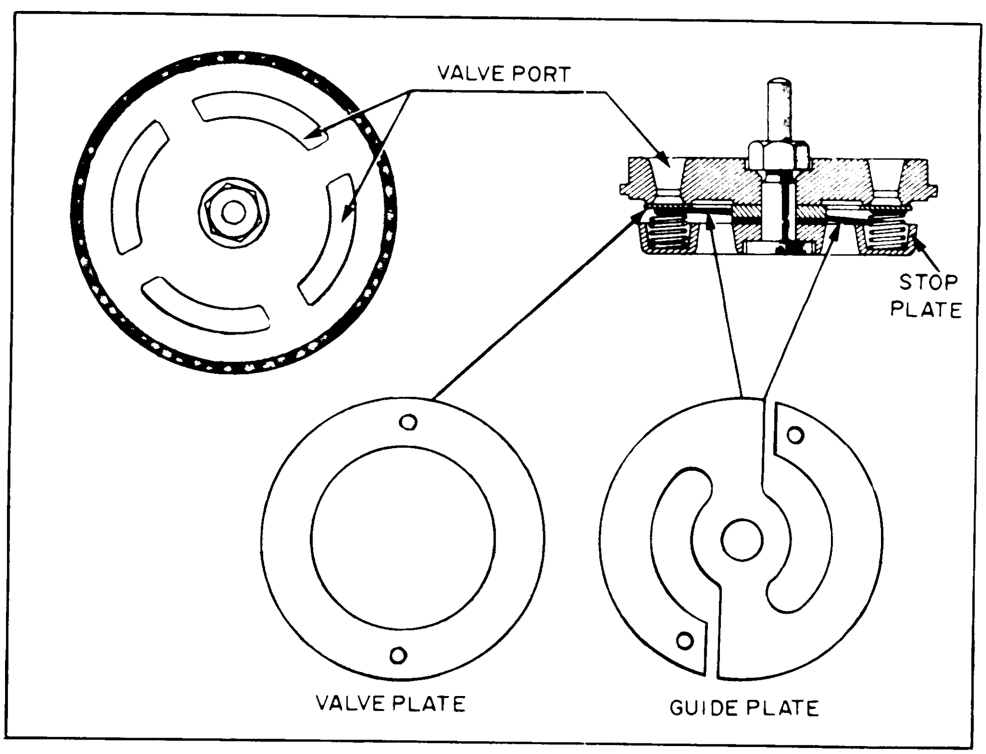

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Figure 11-21.—Thin plate, low-lift, compressor valve assembly.

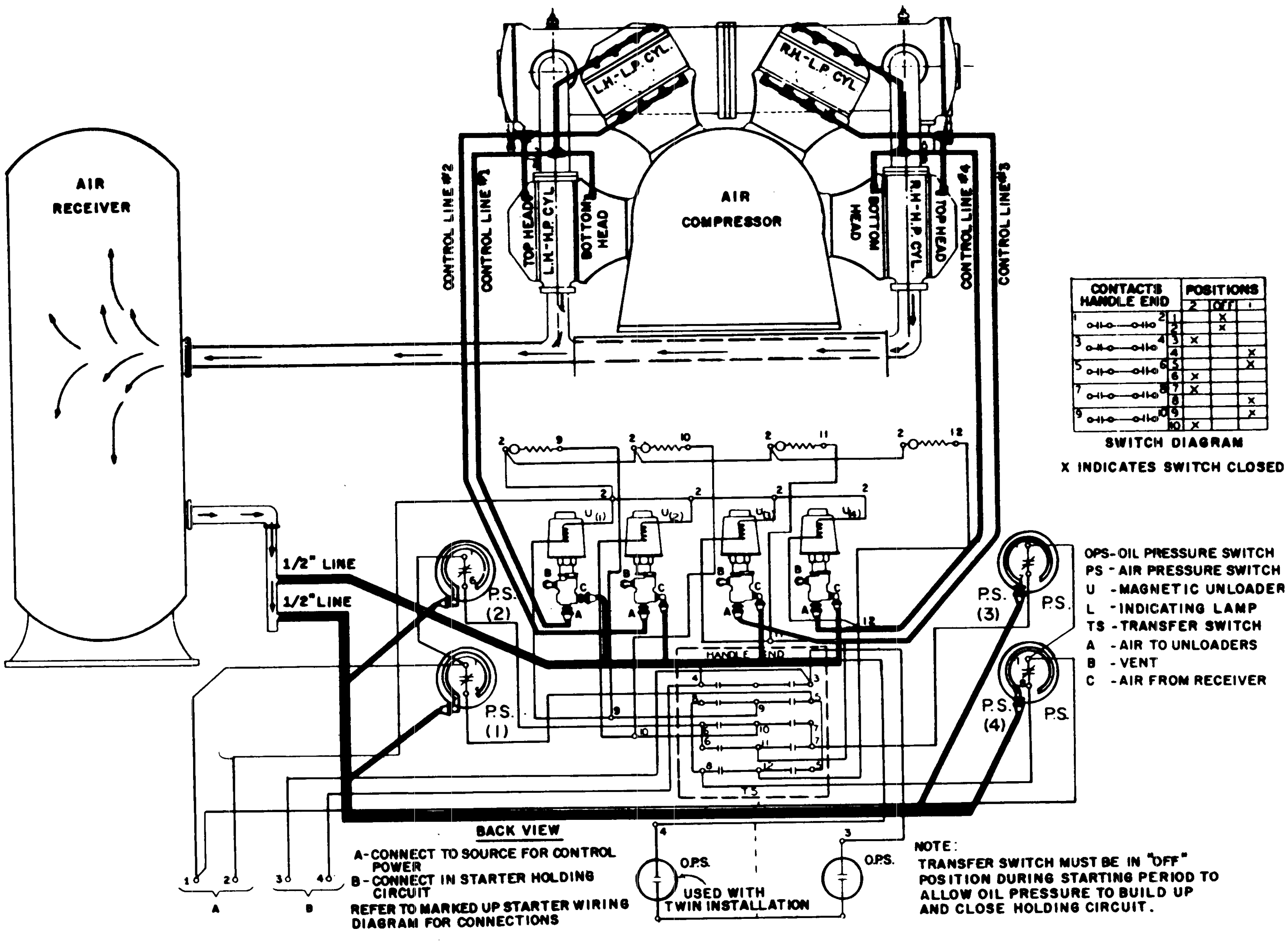

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Figure 11-22.—Five-step capacity control.

five-step capacity control system applied to a two-stage, four-cylinder, double-acting, reciprocating compressor. Assuming that the compressor in the figure is required to maintain a pressure of 92 to 100 psi, the pressure switches should be set to load and unload as follows: switch 1, load at 93 psi and unload at 97 psi; switch 2, load at 94 psi and unload at 98 psi; switch 3, load at 95 psi and unload at 99 psi; and switch 4, load at 96 psi and unload at 100 psi. As the receiver pressure reaches the high limit of each pressure switch, 25 percent of the compressor capacity will unload. As receiver pressure falls to the low setting of each switch, 25 percent of the compressor capacity will load. Pressure switch 1 will therefore unload 25 percent of the compressor capacity at 97 psi and will load 25 percent at 93 psi, and so forth. As receiver pressure fluctuates between 93 and 100 psi, the compressor capacity varies in five steps; full, 75 percent, 50 percent, 25 percent, and zero capacity.

The compressor illustrated in figure 11-22 operates on the following principle: When it is started, air pressure switches are closed and the solenoids in the unloader valves become energized so that receiver pressure cannot enter the unloading lines, and compression is permitted. As the receiver pressure builds up and reaches 97 psi, pressure switch 1 breaks contact, de-energizing unloader 1, and allowing 97 psi receiver air to enter control line 1, actuating the inlet valve unloader. Twenty-five percent of the compressor has become unloaded and compression has reduced from full to 75-percent capacity. Control lines 2, 3, and 4 will operate in the same way as receiver pressure increases. At 100 psi, all cylinders will be unloaded. Air compression ceases, but the compressor continues to run under no load. As air is drawn off from the receiver, the pressure begins to drop. When the pressure falls to 96 psi, pressure switch 4 makes contact and energizes unloading valve 4, which cuts off receiver pressure from the inlet unloader and vents the unloader pressure to the atmosphere. The inlet valve unloader releases the inlet valve and normal compression takes place, loading the compressor to 25-percent capacity. If the demand for air increases and receiver pressure continues to decrease, control lines 3, 2, and 1 will load in sequence.

Another method of unloading a compressor is by the use of clearance pockets built into the cylinders. Normal clearance is the volume at the end of the piston and under the valves when the piston is at the end of the COMPRESSION stroke. Figure 11-23 shows an air cylinder with clearance pockets and clearance valves used with a five-step clearance control. Each end of the cylinder is fitted with two clearance pockets that are connected with or cut off from the cylinder by air-operated clearance valves. A regulated device, not shown, which is operated by receiver pressure, uses pilot valves to open and close the clearance pocket valve in the proper sequence. Each clearance pocket can hold one-quarter of the air compressed by the cylinder in one stroke. When both pockets at the end of the cylinder are open, no air is taken into that end of the cylinder. Figure 11-24 illustrates the operation of clearance pockets under five-step clearance control.

Prime Movers

Prime movers for compressors can be electrical, gasoline, or diesel driven. This section will address electrical prime movers only. Gasoline and diesel-driven prime movers are normally the responsibility of the Construction Mechanic. Several types of electric motors can be used to drive compressors: induction, synchronous-wound motor, and direct current (dc) motors.

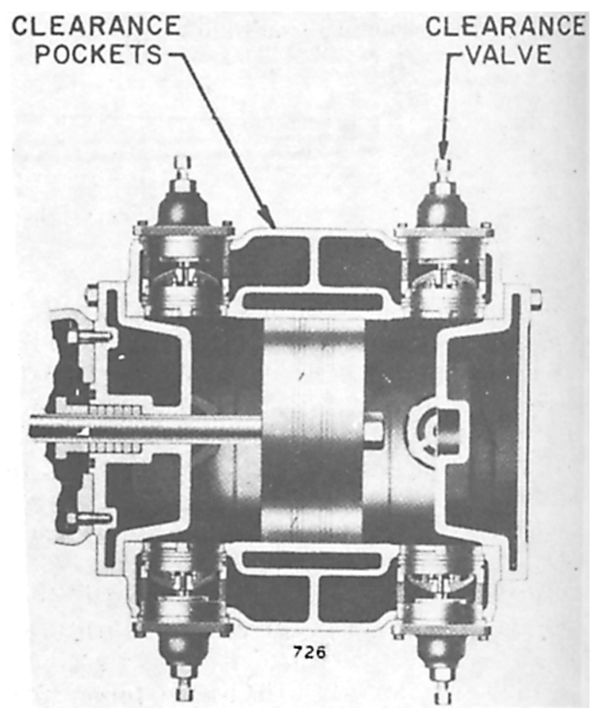

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Figure 11-23.—Air cylinder showing clearance pockets and clearance valves

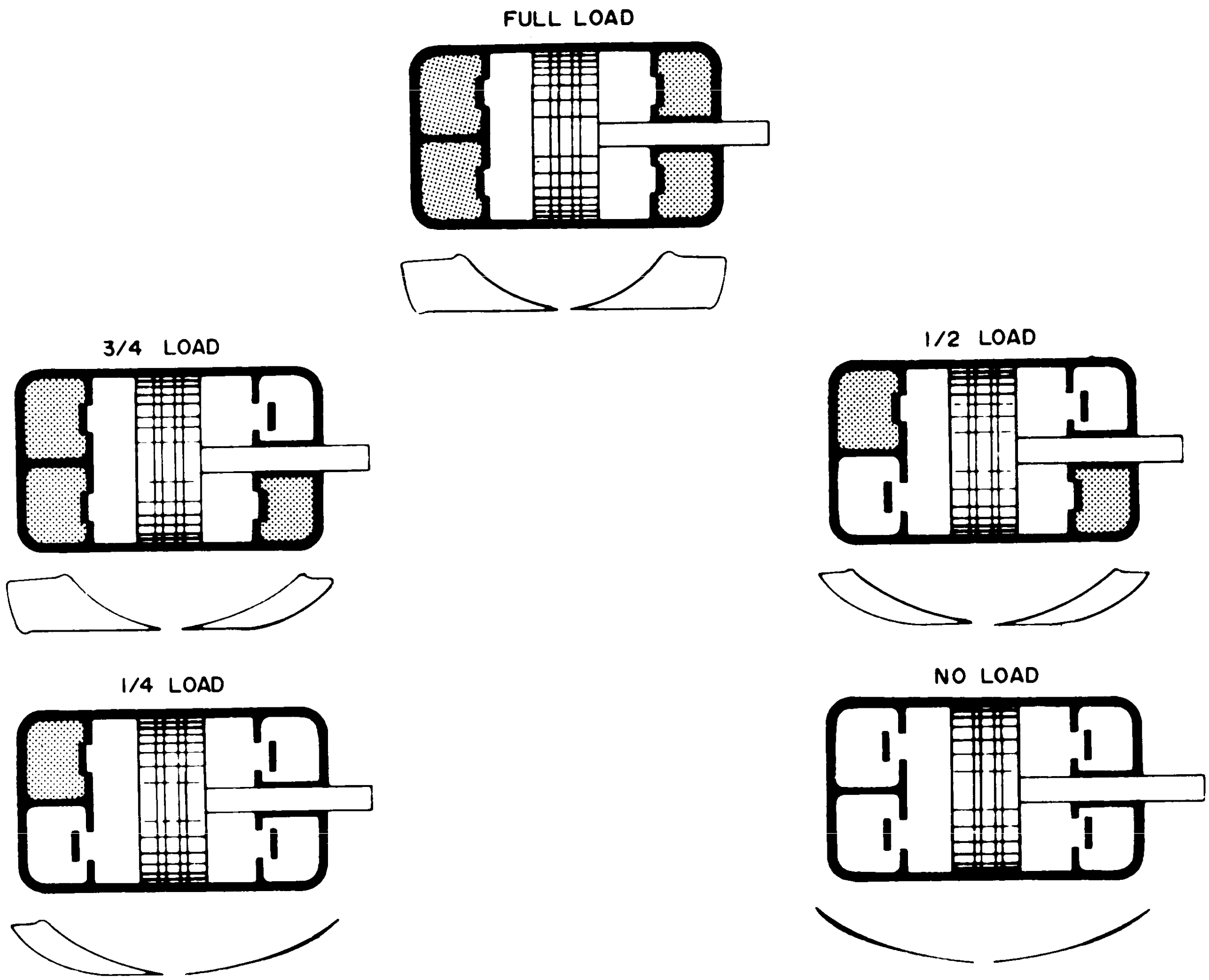

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Figure 11-24.—Five-step clearance control.

Although electric motor drive is available for compressors of almost any capacity, certain types of machines are best driven by an induction motor; others may be driven by a synchronous motor. Generally, cost will rule out synchronous motors except in unusual cases. Direct current motors are seldom used.

Motor-driven compressors may be further identified by the type of connection that is used between the motor and compressor. Any one of the following types of drives may be used: belt, direct-connected, or speed reduction gears.

Induction motors can be used to power single-acting reciprocating compressors ranging from fractional horsepower up to approximately 300 horsepower at a speed of 1,800 rpm. Speeds of 1,200 and 900 rpm and lower are sometimes used in higher horsepower applications. When sizing a motor, you must allow for belt or drive losses of power.

Caution must be exercised when large belted motors are used; manufacturer's recommendations should be applied. Most motors that are belted to compressors are rated as normal starting torque, low-starting current motors. Belt selection should be based on a continuous operation rating of at least 125 percent of motor size with 150 percent preferred. Other compressors that start under load may require motors rated as high-start torque, low-starting current. Consideration should be given to compressor inertia and load to avoid lengthy acceleration time. Whenever possible, it is best

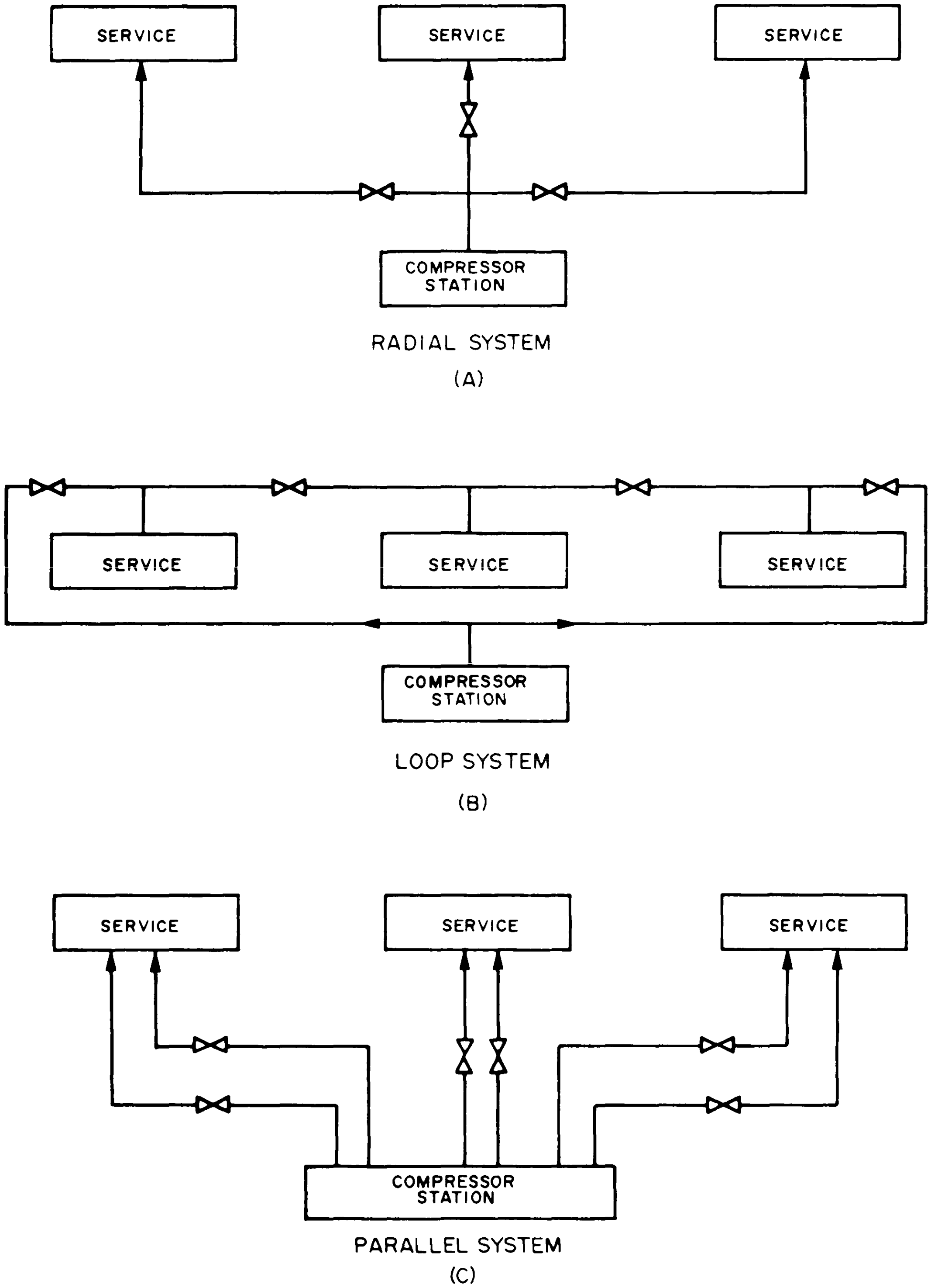

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Figure 11-25.—Types of air distribution systems.

to arrange the compressor to be unloaded during start-up.

A reciprocating compressor maybe driven by an induction motor with a speed reduction gear placed between the motor and compressor. This permits the use of a higher speed with a less costly motor. Gear-driven compressors should have flywheel or inertia effect carefully checked. Couplings should have enough elasticity and dampening to allow for torque and current pulsations. Without this consideration, changes in torque caused by load variations or loading and unloading of a compressor could result in drive and motor damage.

DISTRIBUTION SYSTEMS

The development of a distribution system is dependent upon a combination of factors, such as location and size of each service, time rate demand of larger services, and concurrence or demand factor of larger services.

TYPES OF AIR DISTRIBUTION PIPING SYSTEMS

The more common types of distribution systems or patterns (fig. 11-25) and their prime advantages are as follows:

- Radial, one-way system—used for isolated or individual service or where special requirements dictate a single path.

- Loop system—used for a closed route such as throughout a building. The two-directional flow capacity represents an economical way to provide constant pressure to all services and permits selective isolation when necessary.

- Parallel system—used to provide dual service source to ensure at least one source will be available at all times.

SIZING DISTRIBUTION SYSTEMS

Compressed air distribution systems are sized mainly by calculating the friction loss to be expected from piping, fittings, and valves as well as various accessories you may install.

Pipe diameters are determined from commercially available products, such as copper, stainless steel tubing, or steel piping. As contained pressure increases, the pipe wall thickness must increase and interior diameters decrease. This affects friction pressure loss; it should not exceed 15-percent pressure loss.

When you are determining total friction loss for a distribution system, the total length of the system piping plus the equivalent length of each fitting, valve, or device is summed to produce an equivalent hydraulic length. The equivalent lengths of fittings, valves, and other devices can be determined from table 11-2. Friction loss in air hoses may be taken from table 11-3.

LAYOUT DETAILS

When installing compressed air systems, you must follow seven basic guidelines just as you must consider basic guidelines when installing any other type of piping or drainage system.

Compressed air lines should be installed as level as practical with a slight pitch in the direction of airflow. This pitch is generally placed at 3 inches per 100 feet of piping. In cases when pipes must be pitched upward causing condensate to flow against the flow of air, the pitch upward must be 6 inches or greater per 100 feet, and the piping size should be increased one pipe diameter.

The layout of the piping systems should always allow for the removal of dirt, water, oil, or other foreign material, which can accumulate over long periods of time. Because of this, pockets should be avoided and, where necessary, low points should be provided with driplegs. In addition to providing low points to drain foreign material from the system, the prevention of carry-over of this material into branch lines is necessary. Carry-over into branch lines can be prevented by making connections from the top of the distribution mains.

Piping must be placed with sufficient flexibility to prevent excessive strain or distortion caused by thermal expansion or sudden changes in pressure. By properly placing pipe supports,

Table 11-2.—Representative Equivalent Length in Pipe Diameters (L/D) of Various Valves and Fittings

Description of Product				Equivalent Length in Pipe Diameters (L/D)
Globe Valves	Stem Perpendicular to Run	With no obstruction in flat, bevel, or plug-type seat	Fully open	340
		With wing or pin guided disk	Fully open	450
	Y-Pattern	(No obstruction in flat, bevel, or plug type seat)		
		—With stem 60 degrees from run of pipe line	Fully open	175
		—With stem 45 degrees from run of pipe line	Fully open	145
Angle Valves		With no obstruction in flat, bevel, or plug type seat	Fully open	145
		With wing or pin guided disk	Fully open	200
Gate Valves	Wedge, Disk, Double Disk, or Plug Disk		Fully open	13
			Three-quarters open	35
			One-half open	160
			One-quarter open	900
	Pulp Stock		Fully open	17
			Three-quarters open	50
			One-half open	260
			One-quarter open	1,200
Conduit Pipe Line Gate, Ball, and Plug Valves			Fully open	3**
Check Valves	Conventional Swing		0.5† . . .Fully open	135
	Clearway Swing		0.5† . . .Fully open	50
	Globe Lift or Stop; Stem Perpendicular to Run or Y-Pattern		2.0† . . .Fully open	Same as Globe
	Angle Lift or Stop		2.0† . . .Fully open	Same as Angle
	In-Line Ball		2.5 vertical and 0.25 horizontal† . . .Fully open	150
Foot Valves with Strainer		With poppet lift-type disk	0.3† . . .Fully open	420
		With leather-hinged disk	0.4† . . .Fully open	75
Butterfly Valves (8-inch and larger)			Fully open	40
Cocks	Straight-Through	Rectangular plug port area equal to 100% of pipe area	Fully open	18
	Three-Way	Rectangular plug port are equal to 80% of pipe area (fully open)	Flow straight through	44
			Flow through branch	140
Fittings	90-Degree Standard Elbow			30
	45-Degree Standard Elbow			16
	90-Degree Long Radius Elbow			20
	90-Degree Street Elbow			50
	45-Degree Street Elbow			26
	Square Corner Elbow			57
	Standard Tee	With flow through run		20
		With flow through branch		60
	Close Pattern Return Bend			50

**Exact equivalent length is equal to the length between flange faces or welding ends.

†Minimum calculated pressure drop (psi) across valve to provide sufficient flow to lift disk fully.

87.413

Table 11-3.—Loss of Air Pressure in Hose Caused by Friction

Pulsating flow															
Size of hose, coupled at each end (in.)	Gage pressure at line (lb)	Free air (cfm)													
		20	30	40	50	60	70	80	90	100	110	120	130	140	150
		Loss of pressure (psi) in 50 ft. lengths of hose													
1/2	50	1.8	5.0	10.1	18.1										
	60	1.3	4.0	8.4	14.8	23.4									
	70	1.0	3.4	7.0	12.4	20.0	28.4								
	80	0.9	2.8	6.0	10.8	17.4	25.2	34.6							
	90	0.8	2.4	5.4	9.5	14.8	22.0	30.5	41.0						
	100	0.7	2.3	4.8	8.4	13.3	19.3	27.2	36.6						
	110	0.6	2.0	4.3	7.6	12.0	17.6	24.6	33.3	44.5					
3/4	50	0.4	0.8	1.5	2.4	3.5	4.4	6.5	8.5	11.4	14.2				
	60	0.3	0.6	1.2	1.9	2.8	3.8	5.2	6.8	8.6	11.2				
	70	0.2	0.5	0.9	1.5	2.3	3.2	4.2	5.5	7.0	8.8	11.0			
	80	0.2	0.5	0.8	1.3	1.9	2.8	3.6	4.7	5.8	7.2	8.8	10.6		
	90	0.2	0.4	0.7	1.1	1.6	2.3	3.1	4.0	5.0	6.2	7.5	9.0		
	100	0.2	0.4	0.5	1.0	1.4	2.0	2.7	3.5	4.4	5.4	6.6	7.9	9.4	11.1
	110	0.1	0.3	0.4	0.9	1.3	1.8	2.4	3.1	3.9	4.9	5.9	7.1	8.4	9.9
1	50	0.1	0.2	0.3	0.5	0.8	1.1	1.5	2.0	2.6	3.5	4.9	7.0	...	...
	60	0.1	0.2	0.3	0.4	0.6	0.8	1.2	1.5	2.0	2.6	3.3	4.2	5.5	7.2
	70	...	0.1	0.2	0.4	0.5	0.7	1.0	1.3	1.6	2.0	2.5	3.1	3.8	4.7
	80	...	0.1	0.2	0.3	0.5	0.7	0.8	1.1	1.4	1.7	2.0	2.4	2.7	3.5
	90	...	0.1	0.2	0.3	0.4	0.6	0.7	0.9	1.2	1.4	1.7	2.0	2.4	2.8
	100	...	0.1	0.2	0.2	0.4	0.5	0.6	0.8	1.0	1.2	1.5	1.8	2.1	2.4
	110	...	0.1	0.2	0.2	0.3	0.4	0.6	0.7	0.9	1.1	1.3	1.5	1.8	2.1
1-1/4	50	...	...	0.1	0.2	0.2	0.3	0.4	0.5	0.7	1.1	...	...	...	...
	60	...	...	...	0.1	0.2	0.3	0.3	0.5	0.6	0.8	1.0	1.2	1.5	...
	70	...	...	...	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.7	0.8	1.0	1.3
	80	...	...	...	...	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0
	90	...	...	...	...	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8
	100	...	...	...	...	...	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.6	0.7
	110	...	...	...	...	...	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.6
1-1/2	50	...	...	...	...	...	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.5	0.6
	60	...	...	...	...	...	...	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.5
	70	...	...	...	...	...	...	...	0.1	0.2	0.2	0.2	0.3	0.3	0.4
	80	...	...	...	...	...	...	...	...	0.1	0.2	0.2	0.2	0.3	0.4
	90	...	...	...	...	...	...	...	...	...	0.1	0.2	0.2	0.2	0.3
	100	...	...	...	...	...	...	...	...	...	...	0.1	0.2	0.2	0.2
	110	...	...	...	...	...	...	...	...	...	...	0.1	0.2	0.2	0.2

(1 inch = 25.4 mm, 1 CFM = 0.0283 mm^3/min, 1 psi = 6.90 kPa, 50 feet = 15.2 m)

87.414

as shown in table 11-4, movement of pipe can be accounted for. In addition, piping should be supported at all changes in direction and load concentrations, such as heavy valves.

There are many other considerations in the layout of compressed air systems, which are beyond the scope of this manual. Refer to NAVFAC DM 3-5, *Compressed Air and Vacuum Systems,* for further information.

TEST PROCEDURES

After installation, the compressed air system must undergo testing. Generally, all piping and pressurized components should be tested at 150 percent of maximum working pressure. When testing, use clean, dry air or nitrogen. The system should be held at test pressure without loss for at least 4 hours.

MAINTENANCE REQUIREMENTS

As with any system, preventive maintenance conducted on a scheduled basis is an important factor in providing reliable service. Breakdown maintenance causes interruption in services that

Table 11-4.—Maximum Span for Pipe

DIAMETER INCHES	STD. WT. STEEL PIPE 40 S	COPPER TUBE TYPE K
1/2	5'-0"	3'-9"
3/4	5'-9"	4'-3"
1	6'-6"	5'-0"
1-1/2	7'-6"	5'-9"
2	8'-6"	6'-6"
2-1/2	9'-3"	7'-3"
3	10'-3"	7'-9"
3-1/2	11'-0"	8'-3"
4	11'-6"	9'-0"
5	12'-9"	10'-0"
6	13'-9"	10'-9"
8	15'-6"	
10	17'-0"	
12	18'-3"	

(1 inch = 25.4 mm, 1 foot = 0.3048 m)

87.415

prove costly to the Navy. It also requires more extensive repair to system components. As a senior Utilitiesman, you must be able to coordinate maintenance efforts. An understanding of the maintenance required for each component will assist you in carrying out this type of duty.

PRIME MOVER MAINTENANCE

Air compressors can be driven by diesel, gasoline, and electrical prime movers. These power-producing items of equipment require the same maintenance as any prime mover used to drive other equipment encountered by the Utilitiesman.

Establish a definite lubrication schedule. Normal oil levels in engines must be maintained at all times, using lubricants recommended by the manufacturer. The frequency of oil changes depends on the severity of service, atmospheric dust, and dirt. These factors also affect the filter and in the case of electrical motors, the need for regular lubrication of bearings.

Daily operator maintenance prevents most breakdownsm Following the suggested maintenance requirements of the manufacturer helps to reduce downtime caused by prime mover failure.

AIR COMPRESSOR MAINTENANCE

Taking into consideration the many types of air compressors the Utilitiesman may encounter in the field, it is impossible to cover all the maintenance requirements of air compressors in this section. Several common factors do apply to all compressors.

The establishment of a lubrication schedule is at the top of the list for ensuring trouble-free operation of compressors. A definite schedule and assignment of responsibility for maintenance personnel to follow are required. The manufacturer's manual establishes minimum requirements that should be followed.

Bearings, packing, seals, and clearances between moving parts must be within the manufacturer's specifications and be included on the maintenance schedule. Many compressors allow for adjustment while others require overhaul when clearances are exceeded.

Visual inspections for dust, dirt, or leaks provide early detection of possible maintenance requirements. Operator maintenance, when conducted properly, can help you catch and correct potential problems early. Ensure all of your operators know how to operate the equipment. In all cases, you should use the manufacturer's manual when making repairs or adjustments.

AUXILIARY EQUIPMENT MAINTENANCE

All auxiliary equipment that services the air compressor or is serviced by the compressor requires periodic scheduled maintenance. Air filters should be checked and cleaned at least once a month. Silencers should be checked twice a year for corrosion, paint, and gasket damage. Intercoolers and aftercoolers must be inspected for scale buildup in hub leaks and so forth. In general, all auxiliary equipment must be placed on a schedule for inspection and periodic maintenance.

DISTRIBUTION SYSTEM MAINTENANCE

Distribution systems require a minimum of maintenance. Checking valve operation, hose connecters, draining condensation (manual or automatic), protecting piping from damage, and repairing leaks are the most common considerations in a maintenance plan.

Procedures applicable to the preventive maintenance inspections for compressed air plants can be found in NAVFAC MO 209, *Steam, Hot Water, and Compressed Air* and NAVFAC P-717, *Preventive/Recurring Maintenance Handbook*. For more involved technical maintenance, such as overhauls, make sure competent personnel are trained before they are needed. Again, follow the manufacturer's manual to repair any air compressor component.